LIFT CONTROL OF OVERHEAD MOBILITY AID

MECHATRONICS

INTRODUCTION/MOTIVATION

-Current mobility aids are highly institutional, disregarding the varying level of support required for each user.

-The Adaptable House Project aims to increase independence and confidence in the mobility of individuals by providing full or partial body weight support in a users home.

-This project is one of four subsystems within the Adaptable House Project, and only concerns vertical movement.

Figure 1: Traditional mobility aids [1]

Problem Statement:
The project aims to provide adjustable mobility aid to users in order to assist people facing mobility and strength challenges through overhead suspension.

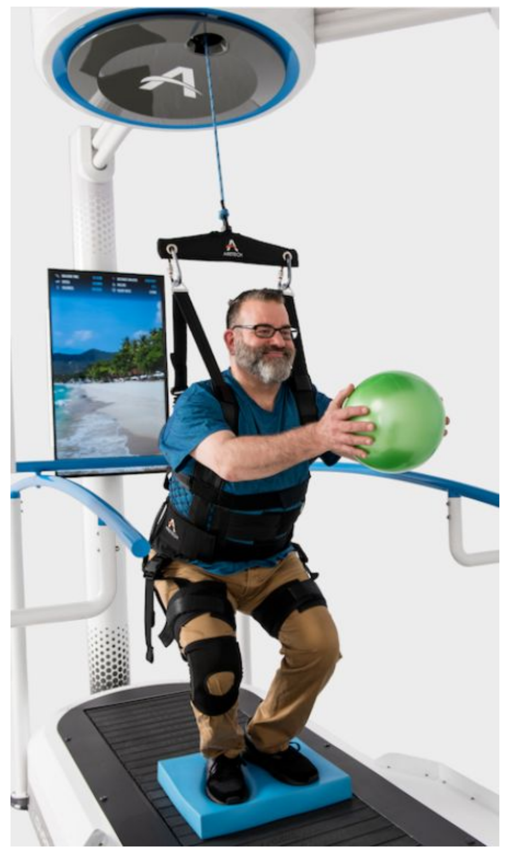


Figure 2: ZeroG's overhead mobility aid [2]

CORE FUNCTIONS

3 USER MODES:

-1. Body Weight Support (BWS): Constantly supports a specified percentage of user's weight.

-2. Fall Protection: Detects the falling user and safely catches them.

-3. Float: Suspends the user for effortless vertical movement.

-The user is able to transition between modes actively or passively.

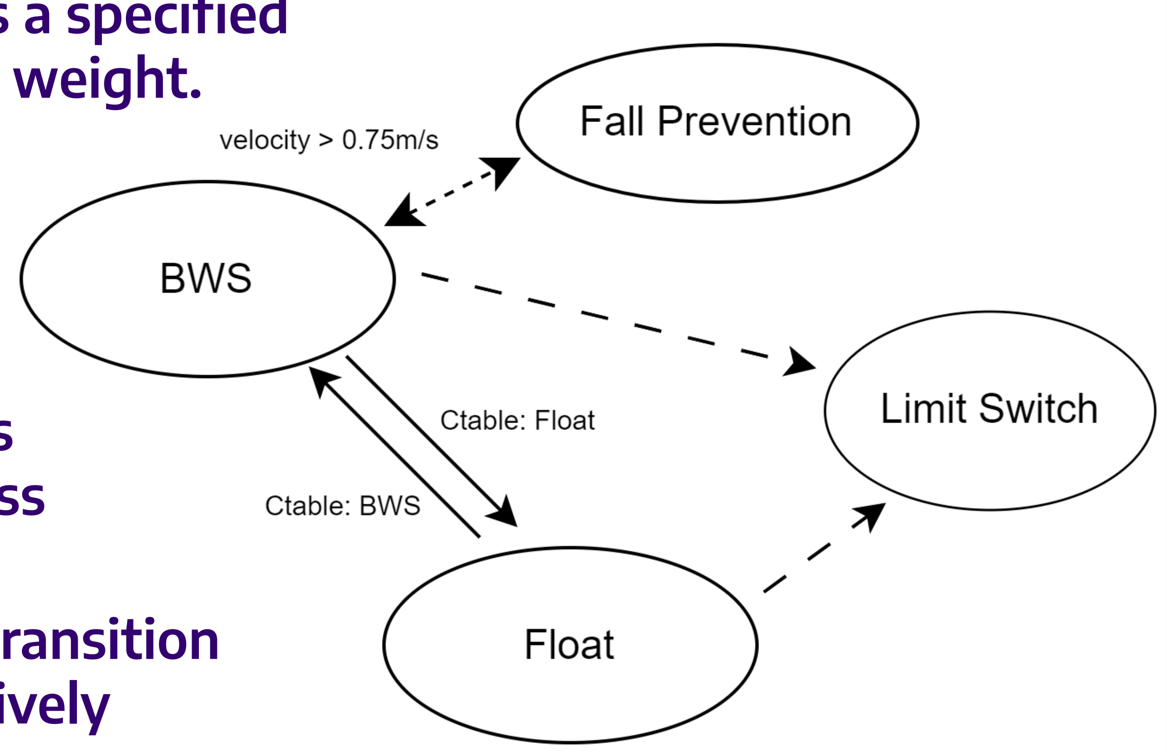


Figure 3: Finite state machine with passive (dotted line) and active transition (solid line)

FUNCTIONAL SPECIFICATIONS:

FLOAT:
-Sat. Velocity: -.15 m/s
-Settling Time: 0.5 s

BWS:
-Max Draw Speed: 0.75 m/s
-Settling Time: 0.1 s

FALL PROTECTION:
-Vel. Threshold: -0.5 m/s
-Max Velocity: 0.3 m/s
-Max Acceleration: 3 m/s^2

DESIGN AND DEVELOPMENT

CONTROLLER:

-Float: External force is proportionally turned into velocity of mass using PD controller

-Fall Protection: LQR and path planning raises falling users safely.

-BWS: Provides constant tension force using a PIDF controller .

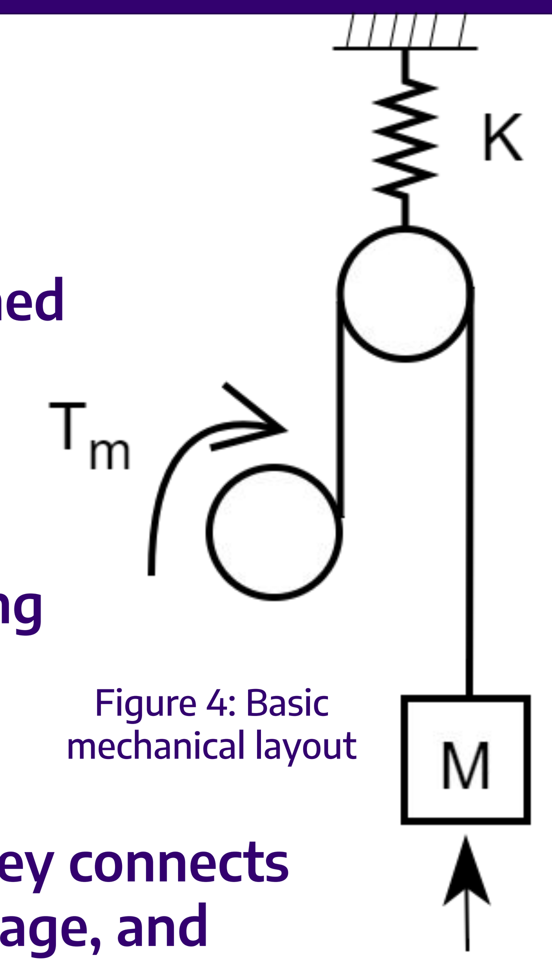


Figure 4: Basic mechanical layout

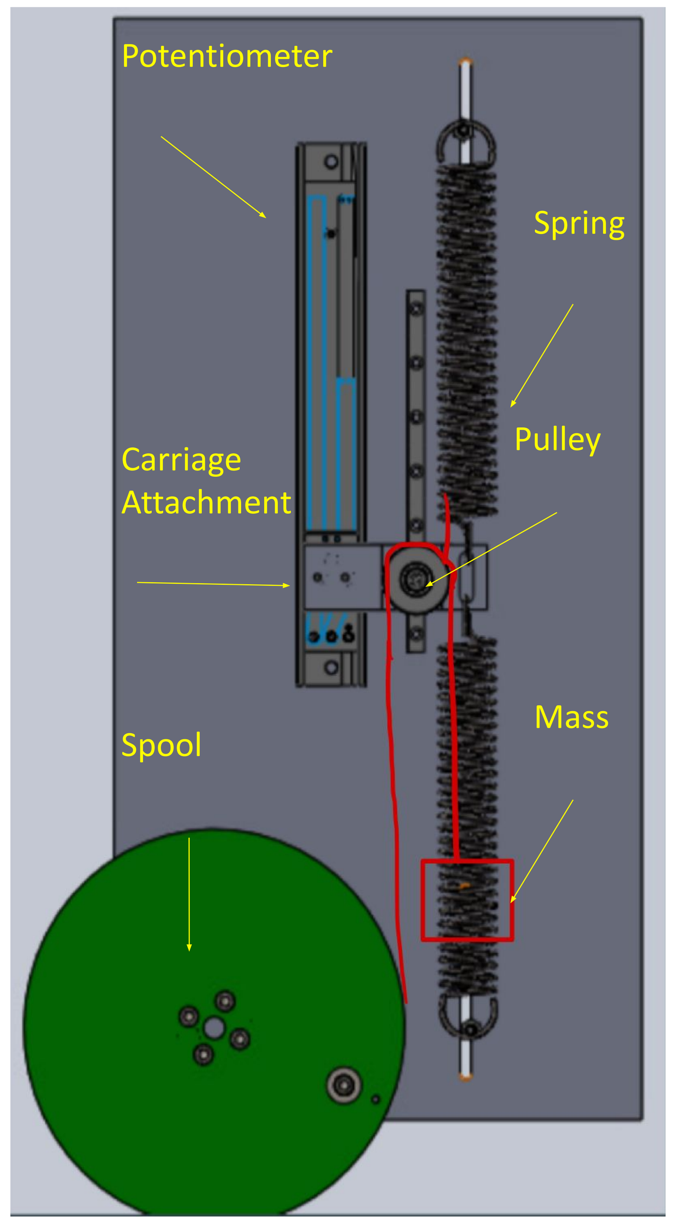


Figure 5: SOLIDWORKS model

MECHANICAL:

-Traversing pulley connects the spring, carriage, and potentiometer.

-Springs acts a series elastic actuator to protect against sudden shocks.

ELECTRICAL:

-The potentiometer measures spring force.

-Printed circuit board with a low pass filter connects to sensors.

EMBEDDED:

-Code constantly calculates the essential state values from the sensors.

Figure 6: Preliminary spool print

Figure 7: Printed circuit board

FINAL DESIGN

-Two springs are used to maintain tension and minimize hysteresis.

-Slotted holes allow for component placement adjustability.

-Addition of a kill switch stops unsafe operations.

-3D printed spool allows for custom torque and speed tradeoff.

-The base plate, carriage attachment, and spacer are machined on a mill.

Figure 8: Base Plate

RESULTS/VALIDATION

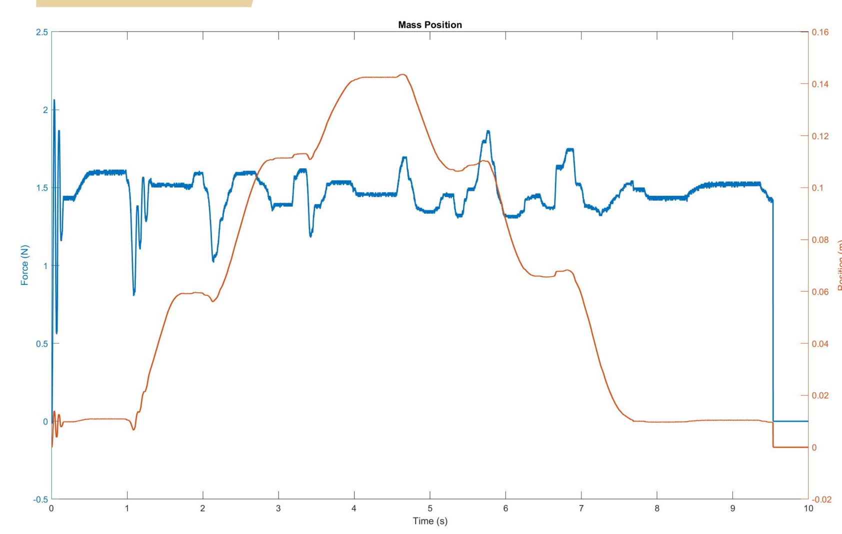


Figure 9: BWS Moving Object Up and Down and Tracking Force in Wire

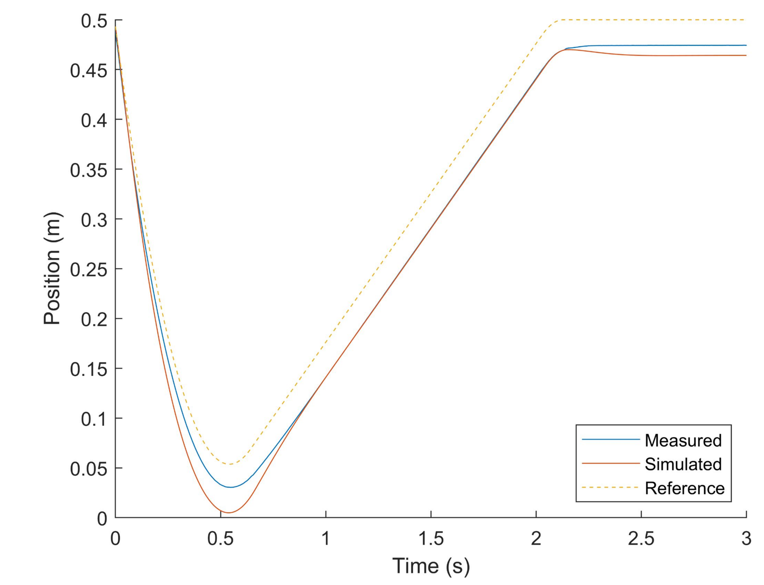
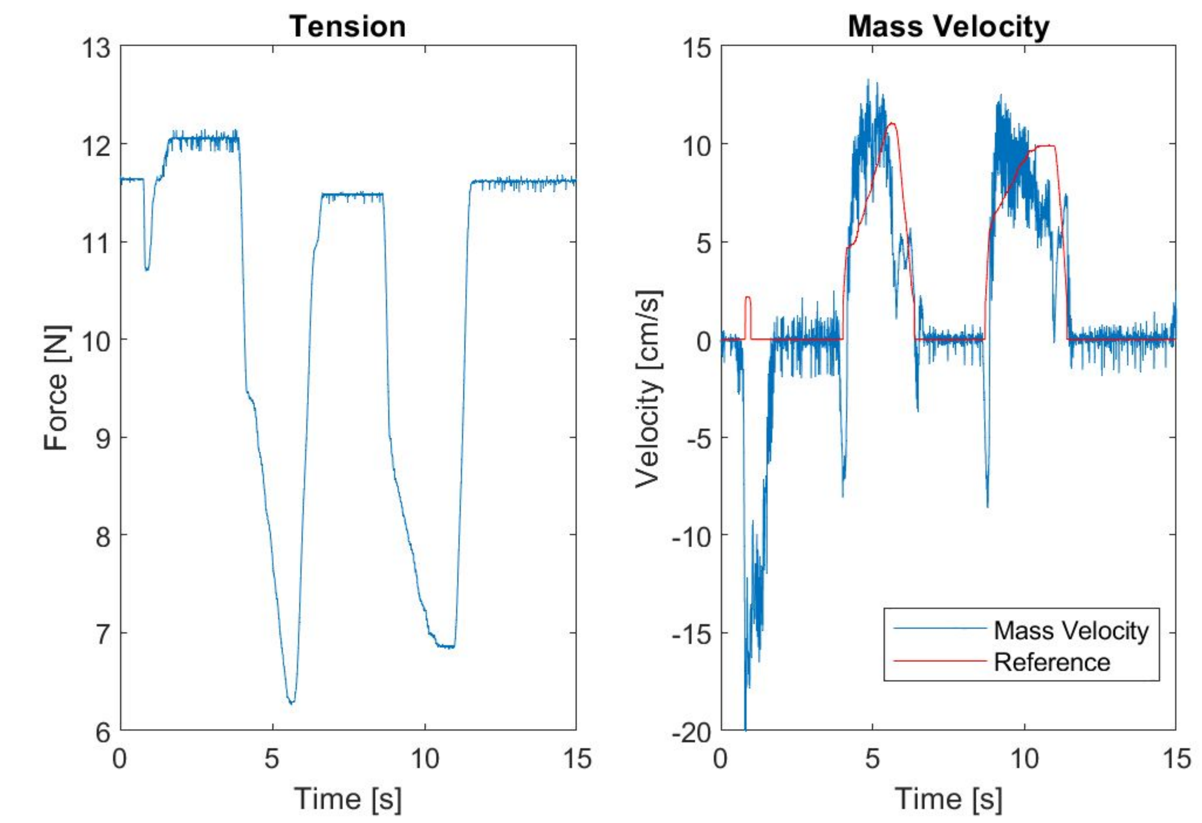


Figure 10: Fall protection tracking mass position for a 0.75m fall of 500g

Figure 11: Float mode tracking the input (Left) wire tension, and changing (Right) the mass velocity



-The system responds appropriately to the external disturbances experienced.

-Fall protection controller exhibits reference tracking performance as simulated.

-Float mode has a force to velocity scaling factor of 0.02

CONCLUSION/FUTURE WORK

- Series elastic actuator is suitable for lifting purpose, but requires high performance motor.

-A force deadzone is added to float mode to prevent unintended movement.

-A low friction angle sensing method for the wire must be identified for integration with the Anti Sway subsystem.

- The design changes associated with scaling up the project must be investigated for safe full scale use.

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Works Cited

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